Northwest Weather and Avalanche Center

Avalanche Glossary

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A

- **Accumulation zone**—in an avalanche path, the main collection area for snow; this zone is often loaded with wind transported snowfall and usually contains the starting zone for a given slide path.
- **Adhesion**—the physical attraction between adjacent surfaces or slabs in the snow. Surface hoar may prevent good adhesion between a bed surface and the overlying snow. Poor adhesion between new snow and a rain or wind crust may also occur when the snowfall starts out at cold temperatures. Contrast with *cohesion* which refers to the physical attraction between crystals or grains within a given snow layer.
- **Age hardening**—the process leading to an increase in snow strength with time following a mechanical disturbance of the snow. The process may extend for weeks following the disturbance, with the rate and ultimate hardness dependent on temperature, among other factors. The exact mechanism remains obscure, although melting is not thought to be necessary for the process to occur. This term derives from the definition of age hardening as applied to metals, namely: *applied to soft or low carbon steels, age hardening relates to slow, gradual changes that take place in properties of steels after the final treatment. These changes, which bring about a condition of increased hardness, elastic limit, and tensile strength with a consequent loss in ductility, occur during the period in which the steel is at normal temperatures.*
- **Airblast**—a strong rush of air produced in front of a fast moving powder avalanche. Potentially destructive forces may be involved with *impact pressures* ranging from 1-10 kPa (strong enough to break doors and windows) up to 1000 kPa (~100 tons force/m^2—strong enough to move reinforced concrete structures)
- **Alpha angle**—for extreme avalanche runouts (very large avalanches having a 50-100 year return period) this is the angle measured from horizontal between the toe of the slide (end of debris) and the top of the starting zone or crown face. This angle typically ranges from about 18 to 22 degrees, and is also referred to as the *runout angle*.
- **Anchor**—terrain, rock, vegetative or other obstacle (natural or artificial) that helps to hold the snowpack in place. Passive avalanche control often involves the installation of artificial anchors or supporting structures (e.g., mounds, terraces, fences, nets) to break up the slab or limit the size of release. Other defense structures are used to channel or divert the avalanche (e.g., dikes, walls and snowsheds) or dissipate its energy (arresters like dams, walls, mounds or trenches)
- **Artificial avalanche or artificial release**—an avalanche triggered directly by man or his (her) equipment (skier, snowmobiler, climber, snowboarder, explosive, ski cut, etc). Artificial releases of avalanches are used for avalanche protections and as tests of snow stability. Common artificial avalanche release methods include protective or test skiing, hand charges and artillery control (see below).
- **Artificial control**—the stabilization of avalanche prone areas by hand charges (explosives), artillery, ski testing, or other non-natural means. This method of avalanche danger mitigation usually results in slope stability through reduction or elimination of stresses within the snow pack by either avalanche release, sluffing or snow settlement.
- **Aspect**—also known as exposure. The direction toward which an (avalanche) slope faces, e.g., north aspect (exposure) slopes face toward the north. Slope aspects are particularly important when considering the effects of solar radiation or wind loading of the snow pack.
- **Avalanche**—(rapid) downhill motion of the snow pack or a portion of the snow pack. This motion may be natural or artificially induced, and controlled or uncontrolled in terms or time, place and severity. Avalanches are often classified according to a variety of factors. These include but are not limited to: time and date of slide release, location, elevation and aspect, type (loose or slab, and if slab type of slab—hard, soft, wet), size (several different size classification schemes exist in North America), content of liquid water in the deposition (dry, moist or wet), type of avalanche trigger (artificial or natural, if artificial note type of trigger), position and depth of sliding surface (new snow, old snow, ground), crown width, vertical fall distance, average and maximum depth of deposited snow.
- **Avalanche airbag**—a flotation device deployed by an avalanche victim that helps the victim float to the surface of a slide before the avalanche comes to rest.
- **Avalanche ball**—a buoyant avalanche protection device (attached to the user via a cord) that may be used to facilitate rescue after an avalanche. A spring loaded nylon ball is deployed by the victim after

being caught; being relatively buoyant, the ball tends to float to the surface of the debris and rescuers are able to find the victim by following the connecting cord.

- **Avalanche beacon**—an electronic device that transmits/receives an electromagnetic signal that facilitates searching for a buried avalanche victim. The buried beacon (in transmit mode) sends out apple shaped magnetic flux lines that the rescue beacon (in receive mode) is able to follow to the source. Searching is accomplished via grid, tangent or flux line methodology (for search examples and some reviews see the following quick reference or practical guide. In no case should a beacon be considered a talisman to ward off avalanches, and a beacon only works well if practiced regularly. All back country travelers are encouraged to carry beacons, probes and shovels as part of standard travel equipment.
- **Avalanche climate—**seasonal weather that allows for development of sufficient snowdepth and snow pack layering that are conducive to instability. This weather and the resulting snow pack must be combined with sufficiently steep terrain to produce avalanche danger. Some regional avalanche climate averages are shown in tabular form in this link.
- **Avalanche control**—form of avalanche protection that attempts to mitigate avalanche danger and/or test snow stability either by artificially triggering slides or limiting their release and motion. Common triggering techniques include artillery, hand charges, slope cuts, and cornice releases while engineering methods are used for *passive control*.
- **Avalanche cycle**—a time of increased avalanche activity spanning a period of hours or days, often triggered by rapid warming, heavy snowfall, and strong winds although other factors may come into play (e.g., surface hoar)
- **Avalanche danger (level)**—a measure of the stability or instability of the snow pack, commonly expressed as a relative level of exposure that a traveler faces in avalanche terrain. Most current regional or national avalanche centers use the internationally accepted 5-level danger scale—low, moderate, considerable, high and extreme avalanche danger. See also the *Evolution Of Public Avalanche Information In North America*.
- **Avalanche hazard**—the combination of terrain (steep slopes), weather and snowpack that result in a threat of avalanches. *Avalanche danger* refers to the temporal changes of this threat to human activity (see *avalanche danger* above).
- **Avalanche path**—the slope areas in mountainous terrain where avalanches occur. The path includes the starting zone (where the avalanche initiates), the track (where the avalanche accelerates and may gather more snow), and the runout (where the avalanche decelerates owing to a decrease in slope angle). These areas include but are not limited to steep open slopes, gullies and bowls. It should be noted that avalanche paths come in a wide variety of shapes and sizes, and the smaller ones should not be overlooked as they claim a disproportionate share of avalanche victims.
- **Avalanche protection**—methods or techniques employed to mitigate the effects of avalanches on humans or their structures. Avalanche protection methods include closures (keeping people and/or their structures out of harm's way), evacuation, land use restrictions or zoning, structure design (e.g., snow fences, diverters, deflectors, splitters, retarders, arresters, terraces, supporting structures, snow sheds jet roofs, vortex generators, etc), avalanche control (artillery, explosives, etc), compaction and education.
- **Avalanche triangle**—the formation of avalanches is composed of the interaction of three basic factors: terrain, weather and snowpack. The avalanche triangle shows the interaction of these three factors with the fourth factor that result in accidents—namely us or the *human factor*. This is a popular teaching point for most avalanche education programs.
- **Avalauncher**—an avalanche control gun that uses compressed gas to fire explosive projectiles into potential avalanche starting zones.
- **Avalung**—a breathing device that helps delay the buildup of carbon dioxide around a buried avalanche victim. The avalung is typically included within a vest or jacket that holds the breathing framework.

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- **Beacon**—a small electronic device (transceiver) that is used to locate buried avalanche victims. Depending on the mode, the beacon either transmits a signal (victim buried) or receives a signal (used by the rescue group). See *avalanche beacon.*
- **Bed surface**—the main sliding surface of an avalanche. Commonly this is a relatively harder and higher density snow layer produced by the effects of wind action, melt, or rain, but it may also be the ground.
- **Beta angle—** the angle measured from horizontal between the place where the runout slope become 10 degrees and the top of the starting zone or crown face.
- **Bonding**—also see sintering. The process whereby individual snow grains come into contact and gradually strengthen the ice skeleton or snow layer(s) through sintering and formation of ice "necks" between the grains.
- **Bridging**—the ability of a relatively stiff (strong) slab to spread increased load (like that of a person or group) over a wider area, making the onset of an avalanche less likely.

- **Bull's eye data**—avalanche data that is termed Class I data and provides strong and reliable evidence of unstable snow. This data provides a direct relationship between loads and weak layers and includes current avalanching, loading tests (ski cuts, explosive, or slope stability tests releasing avalanches), and fracture propagation through shooting cracks or whumpfing.

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- **Cantilever beam test—**most snow stability tests seek to determine location and relative weakness of buried weak layers in the snowpack. However, in some mountainous areas the weak layer is known to exist and is very weak (e.g., depth hoar in Colorado). This slope stability tests seeks to determine the relative tensile strength of the overlying slab by progressively isolating and hence gradually stressing the slab that overlies the weak layer. See snowpack observations for more detailed information.
- **Climax avalanche**—an avalanche that involves more than the most recently deposited snow layer. If a climax avalanche releases all of the season's snowcover, it is also called a "ground avalanche".
- **Cohesion**—bonding within a snow layer or slab, the degree of which helps determine the overall strength of the slab. Cold new low density snow may have little or no cohesion, behaving much like loose dry sand. Conversely, small wind broken snow grains often bond well and have many bonds per unit area, helping to produce a very cohesive slab.
- **Collapse**—sudden settlement of a layer or layers of the snowpack produced by fracture of one or more supporting layers and accompanied by the outrush of air within these layers (see also whumpf)
- **Compression zone**—the area of a slope where the downhill motion of the snowpack is decreasing, normally characterized by a decreasing slope angle. However, compressive forces may also exist on otherwise uniform slopes that have rock outcrops or tree islands that act to decelerate the downhill motion of the snowpack (creep or glide).
- **Compressive strength**—the slope perpendicular strength of a snow layer or crystal that tends to resist further compression.
- **Compressive stress**—the slope perpendicular component of the overlying force acting to compress a snow layer or snow crystal.
- **Compression test**—a slope stability test that seeks to quantify the avalanche danger through application of force to an isolated column of snow. In this test, the blade of a shovel is placed on the top of the excavated/isolated column. The shovel is then tapped by the fingers and hand with a progressively larger application of force by articulating the arm from the wrist (10 taps by the fingers), from the elbow (10 taps from the elbow) and from the shoulder (10 taps). The number of taps necessary before failure on a weak layer represents a relative measure of the slope stability which can be correlated with results of other tests as well as visual observations and knowledge of the overall situation. See snowpack observations for more detailed information.
- **Consolidation**—overall internal compression or settlement that results in a decrease in layer or snowpack thickness. Normally if the consolidation occurs slowly enough, increased strength and stability result.
- **Continental**—mountainous regions in which the winter weather is typically dominated by low temperatures and relatively drier conditions, such as the Rocky Mountains of Colorado, Wyoming and Montana. This weather often produces strong temperature gradients within relatively shallow snow packs that may contain significant layers of weak and well faceted crystals. Depth hoar is common near the ground, especially in wind exposed terrain. Such a snow pack is likely to exhibit significantly more ground or full-depth avalanching than a more maritime or intermountain climate where temperatures are less extreme and deeper snowpacks develop, other factors being equal.
- **Concave (slope)**—an area in which terrain becomes more gentle as you descend, resulting in a shape like the inside of a bowl.
- **Convex (slope)**—an area in which terrain becomes steeper as you descend, resulting in a shape like the outside of a ball
- **Cornice**—snow overhang produced by wind transport of cohesive snow onto the lee side of a ridge. The wind transported snow has normally been broken into smaller grains which adhere relatively well to each other, thus producing a well bonded layer that is often characterized by its overhanging structure. Cornices may store considerable elastic energy as they creep over ridgelines or previous snow layers. As these overhangs may often release naturally or be triggered by the weight of a single skier, snowboarder, climber, hiker, snowshoer or snowmobile well back from their edge, often releasing slabs or loose slides on the slope below, they present a significant problem to recreationists.
- **Corn snow**—snow that has experienced several cycles of thawing and refreezing which results in a rough granular texture, resembling finely chopped ice. Most common during the spring time, good corn snow conditions often result in relatively smooth effortless sliding. Such conditions typically exist in between harder and more refrozen snow surfaces that develop overnight and during early morning hours and the more mush-like and deeper melt surfaces prevalent during mid-late afternoon hours.

- **Cracking**—visual separation of a snow layer identified by a vertical or almost vertical crack in the snow pack. Normally this separation is associated with collapse of a weak layer with the overlying slab beginning to move down slope.
- **Creep**—the internal deformation of a snow layer down slope under the force of gravity. This slow, continuous downhill deformation of the snow pack may be resolved into slope parallel (resulting in shear stress and strain) and slope perpendicular (resulting in compressive forces and settlement) components.
- **Cross loading**—wind blowing across a slope with associated transport of snow developing increased deposition patterns on slopes that are not specifically lee to the prevailing winds (e.g., east facing slopes for a west wind or west facing slopes for an east wind). Such cross loading may occur as a result of wind acceleration and deceleration near minor vertical ridges or gullies on slopes that might otherwise be scoured by incident winds.

  An example of cross loading is local wind deposits to the lee of minor ridges or gullies on a north facing slope affected by predominantly east or west (cross) winds. In this instance local wind loading would mostly likely be found on the northwest (or northeast) side of gullies or vertical ridges exposed to an east (or west wind).
- **Crown—**the snow left behind on the slope above the *crown face* of an avalanche.
- **Crown face** (also crown surface or crown line)—predominantly vertical face of snow that defines the upper portion of a slab avalanche after release. Snow above the crown face (known as the *crown*) is normally more stable than before the slab event took place since a portion of the stresses within the snow pack have either released or been redistributed. However, some "hang-fire" events may still be triggered within the portion of the slab left behind and considerable caution is advised.
- **Crust** (see also *melt-freeze crust, rain crust, sun crust, wind crust*)—a layer of generally hard, cohesive snow formed by wind, rain or melt processes
- **Crystal**—see also *snow crystal*. Any one of a number of macroscopic crystalline forms in which ice appears, including hexagonal columns, hexagonal platelets, dendritic crystal, ice needles and combinations of these forms. Although the crystal lattice of ice is hexagonal in its symmetry, varying conditions of temperature and vapor pressure can lead to growth of crystalline forms in which the simple hexagonal pattern is almost indiscernible. The principal axis (C-axis) of a single crystal of ice is perpendicular to the axis of hexagonal symmetry. Planes perpendicular to this axis are basal planes and present a hexagonal cross-section.

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- **Decomposition**—a transformation of a layer or layers within the snow pack from relatively stable and well bonded to much weaker and more faceted. Decomposition or faceting often initiates at or near the top of a higher density layer (where temperature gradients are strongest) where recrystallization into new grains becomes first evident. If time and necessary temperature gradients continue, the faceting process can slowly work its way down into the layer and introduce vapor transfer and weakening into progressively deeper parts of the layer.
- **Deep slab avalanche**—a relatively large slab avalanche that typically involves snowfall from more than one storm. Deep slab slides are often associated with persistent weak layers that have been buried by subsequent snowfall, such as surface hoar, near surface faceting or depth hoar.
- **Deficit zone**—an area of a slope in which the shear stress exceeds the shear strength. Also called a super-weak zone, "sweet" spot, or trigger point, though "sweet" is no longer preferred as the zone's result (an avalanche) is typically anything but sweet. The existence of deficit zones is a necessary precursor to natural avalanche release, and the snowpack is held in place by tensile strength of the slab or greater shear strength in surrounding areas. When deficit zones grow through a loss of strength or increase in stress, or adjacent deficit zones are linked together (by artificial triggers like skiers, snowboarders, snow machines etc) to a critical size, an avalanche results.
- **Deformation**—change in the shape or dimensions of the snowpack or a layer of the snowpack due to the effects of gravity and compression. Snowpack settlement is an example of a slowly deforming snowpack. Snow layers that deform at different rates on a slope may induce shear stresses between layers which contributes to avalanche release.
- **Delayed action avalanche**—an avalanche that occurs sometime after a storm, (contrast with direct action avalanche)
- **Density**—the relatively amount of water per unit volume of a particular snow accumulation or mass per unit volume of a given quantity of snow. Usually expressed as gm/cm^3 or kg/m^3 the density of a particular layer is computed by dividing the weight of the new snow in grams (water equivalent) by its volume in cubic centimeters. The density of water—which is 1 gm/cm^3 (or 1000 kg/m^3)—is a convenient reference. For instance a 1 x 1 cm column of homogeneous snowfall 30 cm high with a known water equivalent or mass of 3 gm (or .003 kg) has a density of .10 gm/cm^3 or 100 kg/m^3 . This

result in found by calculating the volume of the sample and dividing it into the known weight. Sample volume in cm = 30 x 1 x 1 = 30 cm3 or in m = .3 x .01 x .01 = .0003m). Hence the density is 3gm/30cm^3 = .10 gm/cm^3 or .003 kg/.00003m^3 = 100kg/m^3]. It may also be convenient to express density as a % of water. In the above example, a sample of.10 gm/cm^3 or 100 kg/ m^3 may be referred to as 10% (of the mass of water) snow.
    - In the absence of wind, new snowfall densities usually range from .07 to .12 gm/cm3, (70 to 120 kilograms per cubic meter), while in areas exposed to wind densities are often .20 to .30 gm/cm3 (200-300 kg/m3). In general, high densities of new snowfall correlate with warm air (rimed crystals) or high winds (breakage of crystals), while low densities correlate with cold air (no riming) or low winds (crystals intact). Snowpack settlement also results in increasing snow density.
- **Deposition—**(see also vapor deposition)—mass of snow that is left in the runout or deposition of an avalanche. Also known as deposit, debris or avalanche deposit.
- **Deposition zone**—the lower boundary of an avalanche path in which the slope angle diminishes and the avalanche slows and debris from the slide is deposited. This zone may also occur near benches, natural obstacles or other transitions in slope angle and is often identifiable by forest damage or avalanche deposits.
- **Depth hoar**—large coarse recrystallized grains of snow that are the end result of the faceting or squaring process within the snowpack, a process driven by temperature gradients. Such crystals are often weak and develop as a result of (locally) strong temperature gradients and resulting vapor pressure differences in the snow pack, especially in shallow snowpacks with cold air temperatures. These grains are formed through re-crystallization of existing snow grains as water vapor is transferred (sublimation and deposition) from warmer regions of higher vapor pressure (near the ground) to colder regions with lower vapor pressure (upper layers closer to the snow surface). True depth hoar is most often found in colder climates with relatively shallow snowpacks (e.g., the Rocky Mountains), but may be found in maritime climates early in the season (shallow snowcover) and along the east side of maritime ranges (east slopes of the Cascades or Sierra-Nevada) where snow depths are normally shallower.
- **Direct action avalanche**—an avalanche that occurs during or immediately after a storm, presumably releasing due to the effects (snow loading, wind transport, melt weakening, etc) that may have accompanied the storm
- **Diurnal recrystallization**—the faceting metamorphism of near surface snow (within the upper 15-30 cm) owing to large temperature gradients driven by the daily or dirunal contrast of relatively warm daytime temperatures and cold overnight snow surface temperatures (from radiant heat loss). Clear and relatively warm (but sub-freezing) days followed by clear cold nights helps promote better skiing through near surface faceting..
- **Dry avalanche**—an avalanche that occurs below freezing and involves no liquid water

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- **Elastic**—snow is a visco-elastic material, and the elastic part of snow is responsible for its ability to be able to store energy and propagate fractures.
- **Erosion**—frictional removal of snow by the wind from wind exposed terrain
- **Equi-temperature metamorphism (ET)**—part of the old classification scheme for describing snow metamorphism, the counterpart being known as *temperature gradient metamorphism* (TG). Currently this process (that commonly results in decreasing crystal/grain size and increasing bonding) is known as *equilibrium metamorphism* or *rounding*.
- **Equilibrium metamorphism**—also known as rounding, this is the morphological process in snow crystal evolution in which individual crystals become smaller and round off through vapor diffusion and surface mass migration (primarily due to curvature and shape differences). This process is normally associated with increasing snow layer density and bonding between crystals (grain sintering).
- **Exposure**—the direction a slope is facing, most importantly as it relates to wind and sun. For example, southern exposure slopes receive more solar effects than northern (northern hemisphere), and east and northeast exposure slopes tend to receive more wind transported snow than other exposures in most mid-latitude storm situations (typically associated with west and southwest winds). See also *aspect* or *slope aspect.*

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- **Faceting**—(see also squaring) metamorphic process in the snow cover that results in new crystal growth and/or recrystallization of existing snow grains, often producing general weakening of the snow structure. Faceting is characterized by strong (often local) temperature gradients in the snow pack and resulting strong vapor pressure gradients that move mass from warmer grains (higher vapor pressure) to

colder grains (lower vapor pressure). As the process evolves and more mass is transferred, faceting snow loses existing grain bonds, forms new grains, and in general becomes more disaggregated and sugary (hence the term “sugar snow”). In observations and tests, the hardness of a faceting snow layer decreases with time and it becomes easier to penetrate and pull out of a snowpit wall.

- **Failure**— Snow is one of the earth's natural or geotechnical materials. For a geotechnical material the convention is to define failure as the peak value, on a stress-strain or stress-displacement curve. It represents the maximum load a sample can sustain, beyond which shear deformation increases and strength of the weak layer decreases. In slab avalanche initiation it is the point at which shear stress equals shear strength. It is important to note that failure occurs before fracture, and snowpack failure of the weak layer need not result in visible surface fracture or slab avalanche initiation.

  Failure in alpine snow can take place in shear and tension. In compression (e.g. unconfined compression), slow deformation results in densification to solid ice with no peak attained. For fast compression tests, splitting (some sort of tensile or shear fracture) or diagonal shear failure/fracture results. It is very important to note that in shear, failure is not the same as fracture, particularly in slow tests done at constant rate. In shear, the important deformation mode for avalanches, failure implies that peak strength has been reached but, not necessarily, that the conditions for propagation of an elastic, brittle fracture throughout the sample have been met.
- **Firn**—old settled snow from the previous winter that has become hard, granular and well compacted. It may become a smooth sliding surface for the new winter’s accumulation if initial snowfall does not form a good bond with the firn surface.
- **Flank surface or flank**—the side boundaries of a slab avalanche, often sawtooth shaped, bounded by the crown face at top and the stauchwall at the base of the slab.
- **Flow fingers**—vertical channels of percolating water in a snow pack.
- **Fracture**—fracture means that a sample has undergone a physical separation along a plane in the material. Snow like all materials, can only fracturein shear (in-plane and anti-plane) and in tension. In order for fracture to take place, peak strength must be mobilized and an energy condition must be satisfied for a crack to propagate. In shear and tension, snow is classed as a quasi-brittle material which is evidenced by strain-softening behaviour. A quasi-brittle material is characterized by a finite sized fracture process zone at the tip of the crack. Classical fracture mechanics as developed by Griffith in the 1920's will not strictly apply to quasi-brittle materials such as alpine snow because an infintesimal fracture process zone is assumed. Fracture in snow can take place by ductile processes (glide cracks are examples) with viscous deformation and by elastic, brittle fracture as for the dry slab. Since it is impossible to propagate fractures in compression, "whumphs" are actually propagating shear fractures even if the snowpack load above is in compression, as for example, on flat terrain. Shear stresses developed by other external loads (such as humans) provide the needed shear deformation and the fractures propagate away from the initiation area sometimes accompanied by collapse as the shear fracture cuts through a thick layer. A simple, persistent field observation shows that shear fracture, preceded by shear failure, is the mechanism for release of the dry slab. The fact that the fracture line is perpendicular to the bed implies that the all or nearly all of the bed friction has been removed prior to the tensile failure which is expected as rapid shear fracture sweeps across the bed. The perpendicular fracture line implies that the maximum principal (tensile) stress is parallel to the bed with bed friction removed prior to tensile fracture.
- **Fracture line**—see *crown face*
- **Fracture depth**—the average depth of a slab avalanche, typically the distance measured perpendicular to the sliding surface along the crown face and expressed in cm or meters
- **Fracture line profile**—a graphical representation of the components of a slab avalanche prepared by excavating a snowpit at the crown face and measuring a variety of snow parameters from the surface down at and including the bed surface (and sometimes extending to the ground). Typical parameters measured include time, date, location, weather, slope angle, aspect, slab dimensions, and include the snowpack stratigraphy parameters plotted at the appropriate depth from the surface in cm: density, hardness, temperature, moisture, fracture depth.
- **Free water**—the amount of liquid water present in a given snow sample. For free water to be present the snow layers must be at freezing or liquid (rain) must be infiltrating into the snowpack and bringing the snow layer to freezing.
- **Full-depth avalanche**—a slab avalanche that releases to the ground, also known as a ground avalanche.

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- **Gas Ex (or gaz-ex)—**a remotely controlled explosive avalanche control device placed in a fixed location in an avalanche starting zone. The device uses a mixture of oxygen and propane that when ignited project an explosive gaseous mixture out of the cannon and onto the slope. In most applications, the shock effect of this explosion is approximately equivalent to 15 kg of TNT.

- **Glaze**—when the water droplets striking a surface have sufficient time to flow in a continuous film over the accreting surface prior to freezing, a hard, generally clear and nearly homogeneous ice is formed called glaze ice (or "glare ice" or "black ice" because of its characteristic specular reflection of light; sometimes this glaze is the result of freezing rain.
- **Glide**—slip or sliding of an inclined snowcover relative to the ground, usually a result of both meltwater at the base of the snow pack and a smooth underlying ground surface (like grass, smooth rock). On smooth underlying surfaces, snowpack glide may produce progressively larger lateral cracks in the snow surface which extend to the ground. Such snowpack fracture may result in eventual fracture and sliding of the associated slab if side (flank) or bottom (compressive—stauchwall) anchoring is weakened.
- **Grain**—a mechanically separate unit or particle of ice in the snow cover. Snow crystals evolve into snow grains after their initial shape is destroyed by metamorphism. Also see *snow grain*.
- **Grain bond**—the interconnection between grains, usually neck-like and narrow
- **Graupel (snow pellets)**—precipitation consisting of white, opaque approximately round (sometimes conical) ice particles having a snow-like texture, and about 2-5 mm in diameter. Snow pellets are crisp and easily crushed, differing in this respect from snow grains. They rebound when they fall on a hard surface and often break up. In most cases, snow pellets or graupel fall in shower form, often before or together with snow, and chiefly on occasions when the surface temperature is at or slightly below 0º C. Graupel is formed as a result of accretion of super-cooled water vapor droplets on what is initially a falling ice crystal and are most common when large vertical updrafts are present in the atmosphere.
- **Grid search**—a technique of beacon or transceiver search in which the searcher hones in on the buried beacon though a series of progressively smaller boxes or grids, dictated by the increasing or decreasing signal strength picked up by the search beacon. While this technique has been largely supplanted by the normally more efficient induction or flux/tangent line methods popular with digital beacons, it is still in use by many professionals (who have perfected it with good results), and it is still preferred for final close-in locating.
- **Ground avalanche**—a climax avalanche that releases to or whose bed surface is the ground.

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- **Hang fire**—following a slab avalanche release, hang fire refers to the portion of a slope that does not release and may still be unstable. Hang fires may release either naturally or artificially following the initial event.
- **Hard slab**—a snow slab having a relatively high density (in excess of 300 kg/m^3) usually formed by the mechanical action of high winds on eroded snow or by the effect of compaction. Avalanches involving hard slabs usually retain hard angular blocks within the resulting debris, but this may be tempered by the length and shape of the slide path.
- **Hardness**—(often expressed as hand hardness) a measure of the relative strength of snow determined by pushing a specified object into a given snow layer (typically inserted parallel to the snow slope in the side wall of a snow pit) with a (moderate) force of about 5 kg (about the force needed to feel the bones on one's face). In hard snow, for example, a pencil can be pushed into the snow, but with the same pressure a finger cannot. The following relative hand hardness classifications are internationally understood and accepted (minor adaptations of + and – are often added to the categories as appropriate):

Hand Hardness Descriptor	**Hand Test Method**
Very soft	Fist (F)
Soft	Four Fingers (4F)
Medium hard	One Finger (1F)
Hard	Pencil (P)
Very hard (ice)	Knife (K)

- **Hasty search—**a rescue procedure for quickly searching, scuffing and spot-probing an area of avalanche debris, prior to establishing a *probe line* or dog search.
- **Human triggered avalanche**—an avalanche (loose or slab) triggered by humans and their activities (though not by explosives)
- **Human factors**—the avalanche triangle is formed through the interaction of terrain, snowpack and weather factors. However, no matter how much training or education is involved in any avalanche accident, the *human factor* (in the middle of the triangle) is thought to play a very large role. To quote a saying used to sum up many avalanche accidents: "*We have met the enemy and it is us*!"
- **Hollow sounding**—the sound given off by a snowpack in which a relatively hard layer overlies a much weaker layer (like a drum membrane over air). The sound is due to compression of air within the weaker layer as the overlying hard layer presses down upon it. Hollow sounding snowpacks should raise "red

lights" for anyone venturing into the back country, as this is often associated with an extremely unstable snowpack.

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- **Ice lens**—a clear layer of refrozen melt water within a snowpack, normally produced by rain or freezing rain
- **Induction line search**—an avalanche beacon rescue technique (also termed flux line search) in which the rescuer follows induction or flux lines emanating from the buried beacon in order to locate the victim. During this search, the beacon is continuously adjusted to maintain the flux line. Slightly different from tangent-line search in which the rescuer approximates an induction line in to the victim by following a series of short straight line segments that intersect the flux line.
- **Impact pressure**—force per unit are exerted on an object by an avalanche. Usually this pressure is defined as ρv^2 and is given as an average over the time of the avalanche event.
- **Inter-mountain**—a mountainous region which may have winters characterized by both warmer and wetter periods and relatively dry cold periods. Such regions are typified by the Wasatch and Uinta Ranges of central Utah. A generally deeper snow pack often results; while significant faceting and full depth avalanching may occur, the frequency of such avalanching may be moderated by periods of relatively warmer and wetter weather that create stronger layers which may help minimize the size or depth of ensuing avalanches.
- **Isothermal**—of equal or constant temperature throughout a snow layer or snowpack, usually referring to 0º C. When the snowpack becomes isothermal (in the spring) further heat input goes into melt rather than into raising the temperature of the snow, and this can result in an increase in the potential for larger full depth avalanches.

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K

- **Kinetic growth or kinetic metamorphism**—see *faceting*

L

- **Layering**—in general snow is deposited in layers due to variations in wind speed, direction, termperature and precipitation type or intensity during storms. These structural differences in the snowpack result in mechanical differences in strength within and between layers, and a primary causal factors in direct-action avalanches.
- **Lee(ward) slope**—those (avalanche) areas on the down-wind side of ridges and other terrain obstacles where deceleration of wind flow and speed typically deposits deep accumulations of snow. Also, usually refers to those slopes sheltered or protected from the wind—e.g., an east facing slopes is in the lee of a west wind.
- **Loading**—increases in the vertical and/or or slope parallel forces on a snowpack. Loading may be due to natural causes such as through rain or snow deposition through snowfall or wind transport, or may be due to the effects of humans and their actions (e.g., skier, snowboarder, snow machine loading).
- **Limbing**—the removal of tree branches in or along an avalanche path through the destructive forces of sliding snow and/or associated air blast. Limbed trees are common indicators of recent avalanche activity.
- **Loose snow avalanche**—a progressive rupture of the snow cover, starting at a point and fanning out downhill. Loose snow grains start to slip from a point near the surface in this type of avalanche, sweeping progressively more grains with them as they move downhill leaving an inverted V-shaped scar. Loose slides may be sub-classified as dry or wet, according to whether or not liquid water is present.
- **Lubricating layer**—the snow layer involved in avalanche release which, due to its weak internal strength and/or poor bonding to adjacent layers, facilitates the mechanical failure and fracture of a snow slab. Two examples of this lubricating layer are graupel or light, wind deposited snow sandwiched between two more cohesive slab layers. A clearly defined lubricating layer may not always be present in a slab avalanche release. Free water percolation through a snowpack may also produce a lubricating layer just above an impermeable ice lens/crust through mechanical weakening of the snow layer.

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- **Maritime**—refers to the mountain climates characterized by deep winter snowpacks and relatively mild winters, such as found in the Washington and Oregon Cascades, Sierra-Nevada range of California, the Coast Range of British Columbia, and the ranges of southeast and south-central Alaska. This climate is often associated with frequent large snowfalls, rain at least several times/year, and dramatic temperature variations close to freezing. While snow pack weaknesses often quickly stabilize, periodic incursions of arctic or semi-arctic weather may produce significant faceting and recrystallization of the snow pack near buried crusts, and surface hoar is a common weak layer.
- **Melt freeze crust**—a usually hard layer within the snowpack which has undergone at least one melt and freeze cycle, and has gained strong inter-granular bonding through refreezing or interstitial liquid water
- **Melt-layer recrystallization**—a faceting and weakening process occurring in near surface snow due to the presence of large temperature gradients between a relatively warm and previously wet snow layer or crust and colder newly deposited snow overlying this layer. Experience and research indicate that recrystallization initially occurs just above the higher density crust, but with time the faceting process gradually eats into and erodes the upper part of the crust. If the gradient is allowed to continue (without further insulation from additional snowfall or moderation of air temperatures) eventually the process will produce decomposition or faceting of the entire crust region.
- **Metamorphism**—change in size and texture (type) of snow on the ground, primarily as a result of temperature and pressure differences between adjacent snow grains and layers and secondarily to overburden pressure of the snow above the affected layer(s). Metamorphism can be either a stabilizing (rounding) or de-stabilizing (faceting) influence, and should be closely monitored so as to track the trend in overall snow pack stability.
- **Meteorological reconstruction**—a method of estimating snow structure through virtual rebuilding of the various layers by analyzing the past weather events that produced the snowpack. Meteorological reconstruction can be used to estimate general snow stratigraphy and the associated stability over a wide area (by assessing past general flow patterns at the 500 mb level); it may also be preformed on smaller regional or meso-scales by application of surface maps, observations and other more specific information.
- **Moisture content**—the relative amount of water in newly falling snow or snow layers. Snowfall with higher moisture content has a higher density, adds more weight to the snow pack, and forms a more dense and typically stronger snow layer, while snow with lower moisture content (lower density) forms lighter, weaker and generally less cohesive layers, other factors being equal.

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- **Natural avalanche**—an avalanche produced by natural or weather driven events as opposed to artificial or human triggered avalanches
- **Near surface faceted snow**—faceted snow formed as a result of strong temperature (and resulting strong vapor pressure) gradients within the upper part of the snowpack (usually in the upper 20-40 cm). Processes that form near surface faceted snow include *radiation recrystallization, melt-layer recrystallization, and diurnal recrystallization.*

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P

- **Passive Avalanche Control—**non-explosive methods for avalanche protection. Engineering works for avalanche protection encompass a variety of functions including prevention (supporting structures, ground modification such as terraces in starting zones) and deflection (deflectors and diverters) of avalanches, facility protection (splitters, snow sheds), and slowing and dissipation of avalanche energy (arresters and retarders like dams, mounds, trenches, etc). Wind modification structures (jet roofs, snow fences) may also be utilized to prevent, redirect or limit amounts of snow that arrive in known starting zones. One of the best passive defenses for avalanche mitigation is forest cover, but high elevation reforestation is typically slow at best (the combination of harsh weather and acid rain may minimize tree growth in many locations) and subsequent avalanches may periodically reduce the newly growing anchors.
- **Percolation**—infiltration of liquid water through a snowpack, normally typified by formation of surface rain runnels (if the source of liquid water is rain) and percolation channels by which the water is routed away from the snow surface. While snow near and within runnels and percolation channels is often

saturated, snow in between runnels and percolation channels may be relatively dry. In most instances, percolation channels are not continuous throughout the snowpack, and may be offset vertically as liquid water encounters and spreads out along more impervious buried ice layers.

- **Persistent weak layer**—most commonly a faceted weak layer in the snowpack that persists for a considerable time. As faceted crystals (such as surface hoar, depth hoar or near surface faceted layers) are often much larger than surrounding snow grains, surface kinetics favor their persistence as initially most mass transfer is away from such grains.
- **Pillow**—see *snow pillow*
- **Pocket of instability**—relatively small areas of unstable snow that exist locally as a result of small scale weather effects interacting with terrain. Such pockets may exist especially within small sun or wind sheltered terrain features.
- **Point release avalanche—** (see loose snow avalanche)
- **Post control release**—a natural or artificially triggered avalanche that releases after application of explosive or other control measures. Such a release may occur minutes or hours after control and is thought to release as a result of internal changes and stress redistribution within the snow cover rather than from its response to changing weather conditions.
- **Probe**—a (sectioned) metal pole that is used for locating buried avalanche victims in avalanche debris. Probes may also be used to locate strong and weak layers within the snowpack and thereby obtain a qualitative feel for structure with depth.
- **Propagation**—the spreading of a crack or fracture within a weak layer or slab. Fracture propagation may result in secondary or sympathetic release of avalanches within adjacent terrain.
- **Protective skiing**—deliberate and regular skiing of avalanche slopes in an attempt to break up slabs into smaller pieces and stabilize the slope. This also has the benefit of releasing smaller slabs and helping minimize build-up of larger avalanche events. The process is ineffective and not recommended for hard slabs. Contrast with *test skiing*.

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R

- **Radiation recrystallization—**metamorphic process of near surface snow in which faceting takes place on southerly aspects in response to a delicate balance between incoming solar radiation and outgoing longwave radiation. Significant faceting can result from the intense temperature gradients (in excess of 1-200º C/m) that are produced within a few cm of the snow surface as solar radiation reaches sub-surface snow and heats it to near freezing while at the same time clear skies allow for strong heat loss of the surface snow.
- **Rain crust**—refrozen layer in which the source of liquid water is rain
- **Ram resistance**—a measure of the relative mechanical strength of snow layers. This number is obtained by utilizing the ram penetrometer, an instrument whose measure penetration into the snowpack through application of measured force produces a quantitative plot of relative snow strength.
- **Rate of loading**—time-wise increase in stress to the snowpack and associated weak layers, typically expressed in mm/hr or cm/hr (also in/hr)
- **Remotely triggered avalanche**—an avalanche that is triggered from some distance away by a trigger (person, explosive, cornice fall, etc) other than another avalanche. Contrast with *sympathetic avalanche*.
- **Rime**—super cooled water droplets that rapidly freeze on contact with either snow crystals (resulting in rimed crystals or ultimately graupel) or ground based objects such as trees, power and instrumentation poles, chair lifts and towers, etc resulting in a normally opaque milky or bubbly appearing glaze that grows into the direction of the wind. Large and potentially dangerous accretions of rime growth are possible on the windward side of objects, and such deposits may result in damage to trees, equipment or other structures.

  More technical info—Discrete water droplets in the atmosphere can easily become super cooled because of their small volume. When the super cooled droplets strike a surface they will freeze as soon as the latent heart of fusion is dissipated. “Hard rime” will form when the heat loss is relatively slow, allowing “wet growth” to occur whereby some flow of freezing droplets can occur before complete crystallization. “Soft rime” forms when droplets freeze very rapidly upon deposition, resulting in characteristic granular structure. Hard rime is the denser and harder of the two with densities ranging from about 100-600 kg/m^3; soft rime densities range from about 10 to 80 kg/m^3. Hard rime appears milky or translucent, depending on the amount of air trapped within the structure. Soft rime is more delicate in structure and can appear quite fluffy, though needle-like and lamellar (thin, platelike) forms

also exist. Rime grows principally into the wind, as individual small water droplets impinge on top of one another after coating an accreting surface.

- **Riming**—the process of particle accretion on exposed surfaces by super cooled droplets of fog. Besides coating structures or topography, rime also accretes on snow crystals in the atmosphere. Riming on snow crystals in the atmosphere is thought to play a role in avalanche formation through either its higher density or its promotion of a more slab-like material.
- **Rounding**—metamorphic process within the snowpack that commonly results in settlement (vertical shrinking), sintering, and ultimately stabilization. The rounding process occurs during regimes of small temperature gradients between surrounding grains in which primary mass transfer is dominated by curvature and size effects (vapor transfer from convex to concave surfaces and from small to large grains). Resultant transfer produces a decrease in crystal size, crystal rounding and grain bond formation and growth that increases strength of the rounding layer. This process is also known as *equilibrium metamorphism* and has been known in the past as equi-temperature metamorphism and destructive metamorphism.
- **Runout zone**—the bottom boundary of an avalanche path, generally the lower angled area on a slope in which an avalanche speed decreases and debris is deposited.
- **Runout angle**—see *alpha angle*
- **Rutschblock test—**a slope stability test developed in Switzerland in the 1960's. The test seeks to emulate the force of skiers on a slope by gradually increasing stresses on the snowpack. It involves excavation of a 2m by 1.5m block of snow and subsequent progressive stressing of the excavated block by a skier through approach, standing, down-weighting and jumping. Details, pictures and descriptions for this and other slope stability tests can be found on many web locations including snowpack observations.

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- **Shear**—gravity induced, slope parallel force applied to the snowpack that induces stress and ultimately failure and fracture between adjacent layers, most commonly between a slab and underlying weak layer
- **Shear layer**—a buried layer within the snowpack that produces either a weak bond between adjacent layers or poor attachment between layers.
- **Shear quality**—a semi-quantitative measure of the "nature" or ease of fracture when performing shear tests on the snowpack. Shear quality indicators within the US range from Q1 to Q3 as described below and give additional useful information about snowpack stability beyond the test scores. Other factors being equal a Q1 shear observed for a particular layer connotes a greater likelihood for human triggering of avalanches involving that weak layer than a Q2 or Q3. For further information on shear quality, consult *Johnson and Birkeland, 2002*[1]; for rough stability correlations among common shear tests, consult *Moore, 2004*.

    - **Q1— Unusually clean, planar, smooth and fast shear surface;** weak layer may collapse during fracture and slab may slide into pit on slopes angles > 35°
    - **Q2—Average" shear, mostly smooth** but slab does not slide as readily as Q1; fracture occurs throughout most of slab but some small irregularities possible—not as many as Q3
    - **Q3— non-planar shear surface, uneven, irregular and rough**; shear fracture typically not through the whole slab/weak layer interface. Slab may experience only slight movement

- **Shear strength**—a measure of the bond strength or resistance to slippage between two adjacent snow layers. In a snow slab, the slope parallel component of gravity tends to pull the slab downhill while friction and cohesion (shear strength) between snow surfaces act to hold the slab in place. Slippage between the slab and its undersurface can result, and avalanching can result if gravity induced shear stress between layers exceeds the shear strength bonding snow layers together and the tensile, compressive and flank strengths of the slab are not sufficient to hold it in place. Snow layers composed of surface hoar, low density snow, graupel have very low shear strength.
- **Shear stress**—the gravity force or pressure acting to weaken and fracture the bond between adjacent snow layers, normally applied in a slope parallel direction. Shear stresses between a slab and underlying layer exert pressure upon the two contacting surfaces to slide upon each other, moving apart in opposite directions parallel to the plane of their contact. Such stress normally develops between adjacent layers due to differential strengths and associated variable creep rates.
- **Shovel**—one of the required tools for back country travelers (others include a probe and beacon). A shovel can be used to investigate layering, structure and stability of the snowpack and is indispensable for rescue work when digging in avalanche debris.

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[1] Johnson, R.F. and K.W. Birkeland. 2002. Integrating shear quality into stability test results. *Proceedings of the 2002 International Snow Science Workshop*, Penticton, BC, Canada 508-513.

- **Shovel shear test**—a stability evaluation technique that seeks to find buried weak layers. The test estimates the relative weakness of layers by observing the amount of force applied to an isolated snow column before failure of overlying layers occurs. This is accomplished through insertion of the shovel behind the column and drawing the shovel forward. See snowpack observations for methodology and pictures.
- **Shooting cracks**—fast moving lateral fractures that spread out from a trigger point, typically indicating that the bed surface has failed in shear, the slab has stored considerable elastic energy, and generally extremely unstable snow. Shooting cracks and *whumpfing* may often observed together.
- **Sintering**—preferential transfer of water vapor through a snowpack that results in the formation of bonds between snow grains and gradual strengthening of the surrounding snowpack structure
- **Slab**—a cohesive layer of snow that acts together when failing after stresses are applied. A slab may be either soft or hard, the main concern being its attachment to the underlying snow surface.
- **Slab avalanche**—an avalanche in which a mass of snow (the slab) fractures simultaneously and moves downhill. Slabs may release through fracture of one or multiple underlying weak layers.
- **Slide cycle**—a series of avalanche releases during a particular time period, typically triggered by a combination of an existing unstable snow structure and incoming weather events (e.g., warming, rain, heavy loading, etc).
- **Sliding surface**—also known as *bed surface*, the often harder snow layer on which a slab avalanche releases and may scour relatively clean after release.
- **Sluff**—a relatively small and normally harmless loose slide. However, even sluffs can be dangerous if they sweep an unwary traveler into or over a terrain trap like cliffs, rocks, trees or creeks.
- **Slope angle**—see *slope steepness*
- **Slope cut**—a diagonal disruption of the slope by skier or snowboarder or other means in an attempt to trigger an avalanche below the intended line of travel (from safe point to safe point)
- **Slope stability test**—see *snow stability test.*
- **Snow crystal—**type of solid precipitation based on observable form and resulting from variations of temperature and super saturation in the atmosphere during formation. See the International Snow Classification for Seasonal Snow on the Ground.
- **Snow grain**—as opposed to a snow crystal in which original crystalline shapes can be recognized, a snow grain is commonly a snow crystal that has experienced sufficient metamorphism or change so that the original crystal shape is masked or difficult to discern.
- **Slope loading**—increased weight or pressure on a slope that loads or stresses buried weak layers
- **Slope steepness**—a measure of the angle of inclination of the slope on which snow cover resides. The steeper the slope, the more of an impact that gravity produces to deform snow downhill. Slope steepness plays an important and large role in avalanche release, with avalanches (and avalanche accidents) most common on slopes between 30 and 45 degrees, frequent between 25 and 60 degrees, and rarer below 25 degrees and greater than 65 degrees.
- **Snow decomposition—**the mechanical weakening of a snow layer (e.g., a melt-freeze crust) by the action of faceting, where the gradual separation of previously bonded snow grains into individual loose snow grains, or the recrystallization into new snow grains, often occurs.
- **Snow pack factors**—factors of the snow cover that influence snow stability, such as snow depth, distribution (vertical and aerial) of layering, existence of weak layers, and proximity of certain areas to ridges, trees, rocks and other anchors or snow cover influences
- **Snow pack instability**—a measure of how unstable the snow pack is. Also see *snow stability*
- **Snow pack stratigraphy**—description of layering or the vertical structure of layers within the snowpack. Vertical layering information helps to understand and determine overall snowpack stability or instability and is typically plotted in snow profile books along with temperature, density, hardness, shear information, crystal type and size along with other pertinent information. Also known as *snowpack structure*.
- **Snow pack structure**—see *snow pack stratigraphy*
- **Snow pellet**—see *graupel*.
- **Snow pillow**—(also known as snow drift) a locally larger accumulation of snow to the lee of an obstacle. Pillows are normally the end result of wind erosion on wind exposed terrain, transport over and around the obstacle and subsequent deposition to the lee of the feature as the wind speed decreases.
- **Snow profile**—methodology for assessing snow layer distribution and relative strength that gives insight into stability of the nearby snowpack on similar slope angles and exposures. A variety of shear and stability tests are commonly used in producing snow profiles, with a graphical depiction of the snowpack often resulting.
- **Snow stability**—a relative measure of the ability of the snowpack in a given location to produce avalanching. In most contexts, snow stability refers to the potential for *slab avalanche* release and the nature of the trigger(s) necessary to initiate such a release. Such triggers may be either natural or artificial/human. See *avalanche danger rating levels* and *snow stability tests*..

- **Snow stability tests**—evaluation and/or examinations of the snowpack to determine the likelihood of avalanche release. Such analyses typically involve applying stress to the snowpack and suspect weaknesses in a variety of accepted methods including *test skiing, hand shears, shove shear, rutschblock test, compression test, stuffblock test, cantilever beam test,* and others. It is commonly thought that stability evaluation is a process the needs constant updating (owing to a continual interaction of snowpack, weather and terrain), and should never rely solely on the results of a particular test at a particular location Spatial variation of weak layers and weak layer loading has been documented to be a significant factor with slope stability often varying dramatically over very short distances. See the excellent snowpack observations section in the "*Snow, Weather and Avalanches: Observational Guidelines for Avalanche Programs in the United States*"—a manual produced through the cooperative efforts of the American Avalanche Association and the National Avalanche Center.
- **Snow surface**—the texture and type of the existing snow surface. This description may include information like general type of surface (melt freeze crust, loose new snow, etc), hardness, grain or crystal type and size, density, roughness, penetration resistance; the surface characteristics and type may vary considerably with slope aspect and elevation. While the existing snow surface may be relatively stable (strong refrozen rain crust, ice lens, surface hoar) in its present state, the surface may not be conducive to continuing stability if loaded by future snowfall (wind slab over surface hoar) or a poor bond develops with subsequent snow deposits (smooth hard crust under wind slab).
- **Snow texture**—the inter-granular relationship; the size, shape and arrangement of grains as seen with a hand lens. Also the overall feel of a snow layer, specifically the relative quantities of the different types and sizes of snow particles in a particular layer. A layer of small grained moist snow has a distinctly different texture—much more cohesive and able to make snowballs—than well faceted snow that falls apart in one's hands and exhibits very little adherence.
- **Soft slab**—a snow slab with a density generally less than about 300 kg/m^3. A soft slab will normally disintegrate into loose material shortly after the slide initiates and it may provide good skiing or boarding prior to the slide release. For slab avalanche release it must be remembered that the slab just needs to be a little more cohesive than the layer underneath for unstable conditions to develop.
- **Squaring**—a temperature gradient driven process occurring within the snowpack that leads to angular grain growth (squaring) and resultant weakening of the snowpack structure. See *faceting*.
- **Spatial variability**—the increasingly documented fact that snow layering and associated stability varies dramatically over space. See the paper "Variations in snow strength and stability on uniform slopes."
- **Spring avalanche**—a slide that releases during the spring, often involving weaknesses associated with melt and liquid water. Spring avalanches are typically triggered through the action of sunshine and/or diurnal warming. In the instance of solar warming, the snowpack becomes progressively more unstable by aspect during the day, with instability beginning on east and southeast facing slopes during the morning, progressing to southeast and southwest exposures during the middle of the day, and finally becoming maximum on west exposures late in the day.
- **Stabilize**—the process of making the snowpack less prone to avalanching, whether by natural (settlement, refreezing, sintering, etc) or artificial means (explosives, skier compaction, etc).
- **Starting zone**—the portion of an avalanche path where a slide originates. Generally starting zones are bare of trees, steeper than about 30º and receive large amounts of snow. Gullies and bowls are particularly efficient collectors of snow (especially on lee slopes where wind transport occurs) and the tops of these areas make up a large portion of the most active starting zones. Many starting zones are also bounded by cliffs or rock outcrops.
- **Stauchwall**—the downslope fracture surface of a slab avalanche, often difficult to identify since it is usually overridden and obliterated by the sliding blocks of snow.
- **Steep slopes**—see slope steepness. Those avalanche areas where large slab slides are most likely to start during conditions of high to extreme avalanche danger. In general, dangerous slabs most often occur on slopes in the 30-45 degree range. The upper limit of 45 degrees reflects the tendency of snow to sluff gradually off steep slopes. However, wind packed snow often accumulates on steeper terrain (45-60º), and slab avalanches can propagate from higher angled slopes to lower angled terrain.
- **Stepping down**—when multiple weak layers exist in the snowpack, slab avalanche releases may exhibit a stair type structure indicating that the initial slab "stepped down" to lower layers. Commonly, the frictionally induced shear stress of the initial slab in motion moving over lower layers triggers fracture of the lower layer(s).
- **Strain**—change in form or size or both, resulting from applied gravity forces on a snowpack
- **Stratigraphy**—vertical layering or structure within a snowpack, usually composed of intermittent stronger and weaker layers owing either to the prevailing weather at their time of formation or the subsequent weather that has produced metamorphism or changes within the layers.
- **Strength**—inherent capacity of a substance (e.g., snow layers or the snow cover) to resist both external and internal forces and the resultant changes in form or size. Types of snowpack strength which resist deformation or motion are *tensile, shear,* and *compressive.*

- **Stress**—gravity induced force exerted upon the snowpack that tends to strain or deform its shape. The three basic types of stresses that act on a snow pack are compressive (at the base), shear (between layers) and tensile (within a layer).
- **Stuff block test**—a slopes stability test devised by Birkeland and Johnson that seeks to rate snowpack stability by quantifying the load (force) necessary to obtain release of a portion of an isolated column of snow lying above a weak layer. In this case a known load (4.5 kg or 10 pounds of snow) are stuffed into a stuff sack which is then laid upon and then dropped onto an isolated snow column from progressively higher heights until failure occurs. The number obtained is then an approximate measure of snow stability. The test was introduced by Birkeland and Johnson at the 1994 ISSW and is detailed in snowpack observations and the 1999 paper by Birkeland and Johnson.
- **Sun crust**—an often hard, thin layer of refrozen crystals where the source of liquid water is due to surface melt by solar radiation.
- **Sugar snow**—see *depth hoar*. Sugar snow is advanced *faceted snow*, weak in shear with little or no bonds between adjacent grains.
- **Sunballing (sun balls)**—the process in which loose snow rolls downhill during warm weather and forms sometimes large snow rollers. If the sun balls/snow rollers do not produce slide activity, this process can result in stabilization of near surface snow. Once the warming has diminished and cooler weather prevails, the tracks produced by the sun balls often freezes and breaks up any existing slabs.
- **Surface hoar**—also hoarfrost. The ice equivalent of dew. Surface ice crystals resulting from vapor deposition directly onto a cold surface. These crystals are quite intricate, extremely weak and cohesion less (especially in shear), and generally form on clear, cold, relatively still nights with sufficient water vapor in the lower atmosphere. They may grow quite large in the presence of nearby moisture sources such as creeks or lakes and once buried may exist as persistent weak layers in the snowpack for a month or more. While larger hoar frost crystals that form over a period of several days to a week or more are likely to be more persistent and form more suspicious weak layers, small seed crystals that have been documented to produce avalanches may form in less than four hours.
- **Sympathetic (avalanche)**—refers to an avalanche on an adjacent slope that is released by the motion or changing forces from a slide on another slope, often some distance away. Sympathetic fractures need a well defined weak layer and stored elastic energy within the snow slab in order to be widespread. Compare with *remotely triggered avalanche*.

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- **Tangent search—**see *induction line search*
- **Temperature gradient**—in avalanche forecasting, the change in snow temperature over distance, normally expressed as XX degrees C/cm or YY degrees C/m. While most temperature gradients of interest in the snow pack are vertical changes (warmer near the ground, colder near the snow surface), strong nearly horizontal temperature gradients may also exist near obstacles such as rocks or trees that allow outside air to flow into existing holes or cavities.
- **Temperature gradient metamorphism (TG)—**an older term used to describe the faceting or squaring process driven by strong temperature gradients. Currently the terms *kinetic growth* or *faceting* are preferred.
- **Tensile strength—**the slope parallel (downslope) component of strength in a snow layer which prevents it from fracturing across the slope. Tensile strength of the snow slab together with shear and compressive strength act to prevent the slab from avalanching.
- **Tensile stress—**the slope parallel gravity induced force per unit area acting on a snowpack which tends to stretch snow slabs downhill.
- **Tension (zone)—**stress applied to a snow slab in such a way that equal and opposite forces are exerted on its ends along the same line of action, thereby tending to elongate the slab and pull apart composite grains. A snow slab is placed in tension by the straining and stretching of the snowpack. The tension zone of a slab occurs near the top where it is trying to pull away from the quasi-stationary stable (and typically less angled) snow that is stretching more slowly downhill.
- **Terrain**—the shape of the land that influences deposition, distribution, stresses and metamorphism of the snow pack
- **Terrain factors**—any of the numerous characteristics of terrain (slope angle, aspect, configuration, vegetation, roughness, etc) that influence the formation and evolution of the snowpack, including stress distribution and the response of snow layers to the effects of weather and gravity.
- **Terrain trap—**any of a number of terrain features that act to magnify the consequences of being caught in an avalanche. Terrain traps include cliffs, rocks, trees, gullies, creeks, all of which tend to increase the danger of any (even small) slide releases. Such traps may increase burial depth, increase impact or trauma injuries, produce drowning, etc.
- **Test skiing—**an attempt to release avalanches on selected small slopes by skiing across the normal starting zone, and used as an indicator of stability and the possible need for more control measures,

changed route selection, trip rescheduling, etc. Safe test skiing is often used in conjunction with snow stability tests (shear, Rutschblock, etc) to confirm suspicions produced by such tests.

- **Track—**the middle part of an avalanche path between the starting zone where an avalanche initiates and the runout zone where the avalanche slows and comes to rest. An avalanche achieves its maximum speed in the track. Avalanche tracks can be sub-divided into channeled (gullies, gulches, couloirs, etc) or unconfined tracks (plane, open slopes).
- **Transceiver**—see *avalanche beacon*
- **Transport**—movement of snow by the wind; wind transport may involve newly falling snow, or erosion of snow from windward slopes and subsequent deposition onto leeward slopes.
- **Track**—see *avalanche path*
- **Trigger**—the force necessary to produce an avalanche; also the act of releasing an avalanche

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- **Unstable snow conditions—**physical characteristics of the snowpack that may result in avalanching. The presence of faceting, buried surface hoar, whumpfing or shooting cracks all are indicators of unstable snow conditions. Rising temperatures, winds or precipitation intensities during a storm usually produce increasingly unstable snow conditions.

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- **Viscous**—the property of snow that allows for the slow internal deformation of snow layers under the influence of gravity.
- **Visco-elastic**—snow is a visco-elastic material, able to deform slowly (viscous property) and to store energy (elastic property). Whether or not snow layers settle stably in place or fracture elastically is related to changes both in the thermal and mechanical state of the snowpack, especially the rate of stress application (rate of loading), and the rate of temperature change.

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- **Water equivalent—**the amount of water contained in a given snow sample or snowfall, expressed either in mm or tenths of inches. If the height of the new snowfall is known along with the water equivalent (WE) then the density of the snow can be calculated.
- **Weak layer (weak interface)**—a weaker and less cohesive layer of snow that prevents or minimizes bonding between adjacent layers.
- **Weather factors**—any of the numerous weather related parameters that affect the deposition, formation, and evolution of the snow pack over terrain, including its thermal and mechanical properties. Primary weather factors include temperature, wind speed, wind direction, precipitation rate,
- **Wet snow avalanche—**an avalanche consisting of snow that contains liquid water. Also an avalanche caused by snow losing its strength after becoming moist or saturated with water. In some instances, an avalanche will begin as a dry snow avalanche but turn into a wet avalanche as it descends to lower elevations (and as frictional effects heat the moving snow).
- **Whumpfing**—(also spelled whoomph) sudden collapse of a snow slab accompanied by an out rush of air (whumpf) from a buried and less dense layer.
- **Wind loading—**the wind transport of snow onto lee slopes in addition to the accumulation due to snowfall alone. In this interpretation, wind loading can and does occur without precipitation through scouring/erosion of surface snow on exposed windward slopes and subsequent deposition of this mass onto lee slopes.
- **Wind transport—**the movement of snow from windward to leeward slopes.
- **Windward slopes—**those avalanche areas on the upwind (facing into the prevailing wind) side of ridges of other terrain obstacles, where accelerating wind flow can erode loose surface snow, redepositing it in areas of low wind stress (lee slopes).

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Many excellent sites exist to further your knowledge of snow and avalanches. The above glossary is neither exhaustive nor definitive and should be used only as a starting point for your exploration of the topic. Links provided in the education page of the NWAC web site, at www.avalanche.org and the National Avalanche Center should be helpful as well.